new technology

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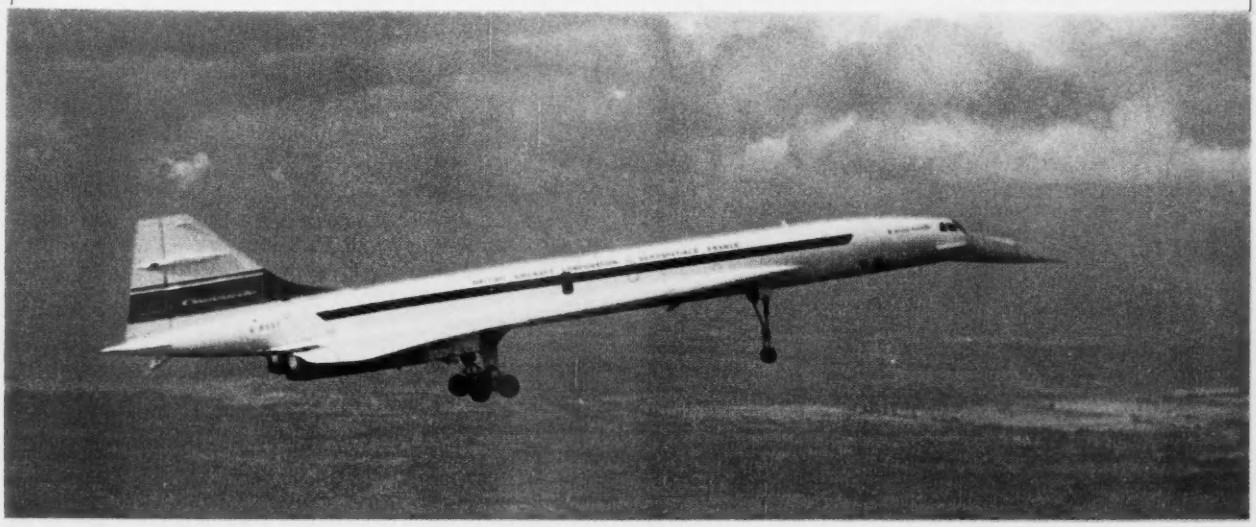


Concorde 001—the first prototype of the Anglo-French supersonic airliner—soars gracefully into the air to begin another of its comprehensive programme of development flights. Orders for Concorde have now been placed by BOAC and Air France. In the summer of 1975 BOAC will have its first twice the speed of sound aircraft in passenger service. The London-New York-London trip will cut, by almost half, today's fastest times: a passenger leaving Sydney in the afternoon will arrive in London the same evening local time, and Concorde will bring dinner in Johannesburg within reach of a businessman who lunches in London.

BRITAIN IN AEROSPACE

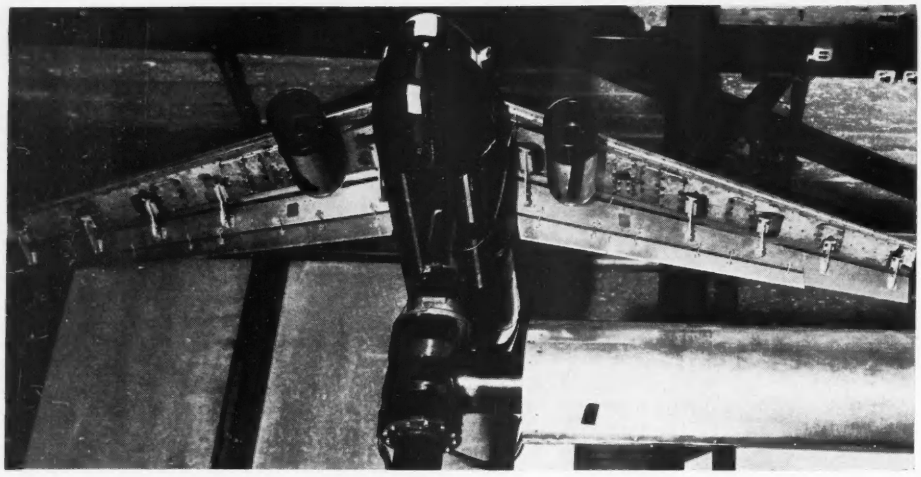
A Report prepared for the Department of Trade and Industry by Laurie Noquet, Central Co-ordination and Information Division

This special edition of New Technology, published on the eve of SBAC's Farnborough Show of 1972, reviews some of the considerable achievements—technical and commercial—of the British aerospace industry.

Government policy for aerospace and sponsorship of the industry is the responsibility of the Department of Trade and Industry, working with the Procurement Executive of the Ministry of Defence and with the Civil Aviation Authority. The edition features the Government's role in the extensive programme for developing substantially quieter aircraft, some of the most important of the civil and military projects now under way (including those involving collaboration with other European countries), and various aspects of United Kingdom space activities.

These projects, and the export achievements to which reference is also made, reflect Britain's impressive aerospace performance and the results of the efforts by industry and Government in this field.

The Queen and Princess Anne inspected Concorde when the aircraft landed at London Airport Heathrow after its first international tour. Her Majesty is seen here with Mr. Michael Heseltine, Minister for Aerospace, Department of Trade and Industry, and Princess Anne with Sir George Edwards, Chairman and Managing Director of the British Aircraft Corporation's Commercial Aircraft Division.



A wind tunnel model of possible short medium haul transport using externally blown flaps for large lift increases. The model is mounted on a large pipe which enters the fuselage and supplies air under high pressure through ducts within the model to engines under the wings to simulate the exhaust from fan-jet engines.

Quieter aircraft—engine and airframe developments

THE Department of Trade and Industry has established the reduction of aircraft noise as one of its prime targets, and the Government is spending £1 million a year on research alone with heavy additional expenditure on capital equipment and its development. In addition to the substantial technical and financial support it is giving to the development of new quiet engines such as the RB211, it sponsors programmes of research and development in the research establishments in the Ministry of Defence Procurement Executive, industry and universities to this end. Nowadays it is the law that civil aircraft must be certified as having noise levels below an internationally agreed figure. Sponsored research in aid of civil aircraft is funded by the DTI. The now familiar 'customer/contractor' relationship is the driving force for the determination of these programmes. The Procurement Executive of the Ministry of Defence, in which are located the aerospace research establishments such as the Royal Aircraft Establishment and the National Gas Turbine Establishment, undertake work and place contracts in industry and at universities on behalf of the DTI.

Quietening existing aircraft

Many of the commercial aircraft flying today are equipped with engines which were designed before recent advances in aero-engine technology made lower noise levels possible. On the early jet engines, the dominant noise source was the high-velocity exhaust from which the aircraft derived its thrust. Attempts were made, with some success, to alleviate jet noise by fitting shaped nozzles to the exhaust which speeded up the mixing process between the jet and the surrounding atmosphere.

These engines have been largely phased out and replaced by the low-bypass engine. In these, the jet velocity is reduced to increase engine efficiency, with an increase in total flow of air through the engine to maintain thrust. It is this reduction in exhaust velocity which has made the major contribution to the quietening of modern jet engines. However, the jet noise suppressor itself becomes less effective as the jet velocity is reduced, so that the full benefit of the reduction in exhaust velocity is not attained.

In addition, the lower jet noise allows the noise of the rotating machinery to become more intrusive. This noise arises from turbulent fluctuations of the airflow through the compressor and fan and the inter-action of the fixed and moving blades. The latter gives rise to the characteristic whistle of many present day aircraft. There are other noise sources present in varying degrees, such as shock waves where the airflow at the blade tips exceeds the local speed of sound, combustion noise and flow turbulence within the engine casing.

The long-term solution to the problem of the noise generated by existing jet transports is to replace them with new quiet aircraft. With the introduction into service of the Lockheed L1011 TriStar this process is already under way, but the numbers of aircraft to be replaced run into many thousands, so that even if the full range of new aircraft types existed in developed form, replacements would take many years.

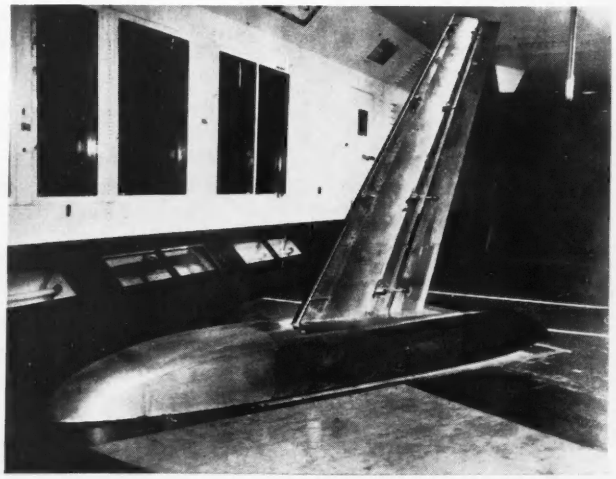
The meaning of retrofit

Meanwhile, what are the prospects for reducing the noise levels of existing aircraft by that modification of existing power plants referred to as a 'retrofit'?

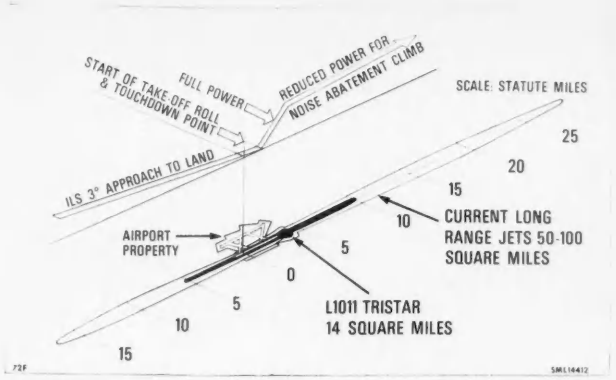
This consists of installing modifications within the engine and nacelle to absorb the noise before it emerges from the engine, rather than eliminating sources of noise as would be done with a new design. It is thus necessarily less effective than the new design which could have retrofit type treatment built in from the start, in addition to incorporating basic design features to reduce the noise at its source. The treatment generally consists of lining the intake and duct passages with sound absorbing panels, changing the internal geometry in critical places and fitting new types of propelling nozzles.

There is no single package of treatment which can be applied to all power plants. Each installation has to be considered separately. On some engines it may be possible to incorporate all the features listed above, and on others only some of them, because of limitations imposed by the basic design, or by the aircraft in which they are installed. The intake and duct linings can only deal with the higher frequency sources and are intended to contain the noise within the engine.

To do this effectively requires extensive modification, in some



A wind tunnel model for research into advanced mechanical flap systems to improve low speed lift



How the new RB-211 engined aircraft drastically reduces aircraft noise around airports is clearly seen in this diagram. The elongated shapes represent the area on the ground where the noise will exceed 90 PNdB.

cases introducing additional surfaces (such as concentric rings in the intake and ducts) whose sole purpose is to carry absorbent material. Treatment of this sort is more easily carried out where the bypass and primary flows are kept separate. New silencing nozzles for the hot jet can be fitted but the potential gains would depend on how efficient the original jet suppressors (if any) were.

Less approach noise

The amount of noise reduction to be gained in this way varies considerably from one engine combination to another. Experimental installations on two types of American four-engined aircraft some years ago showed improvements in approach noise of 10-15 EPNdB (Effective Perceived Noise Decibels) and about 3 EPNdB in take-off noise. More recent forecasts suggest about the same for approach noise and possibly up to about 10 EPNdB at take-off. However, the estimates of what might be achieved on other types of aircraft have been in the region of half these figures, about 5-6 EPNdB at both take-off and approach. (A reduction of 10 EPNdB would be considered as halving the perceived noise.)

No retrokit package which would achieve these noise reductions is yet commercially available. The price to be paid for these changes would be very great, in increased operating costs as well as capital costs. Since existing aircraft will eventually be replaced in any case, the benefits would be transitory. A reduction, through retrofitting, in the noise level of the British fleet alone would be of limited benefit: *at Heathrow 48 per cent of the movements are accounted for by foreign operators.*

It is quite probable that each aircraft type with its own retrofit will show different noise gains and suffer different financial penalties in terms of initial outlay and increased operating costs. These could materially alter the relative competitiveness of airlines operating on the same routes, using similar capacity aircraft of different manufacture.

Problems to overcome

It is thus clear that retrofitting existing aircraft is by no means a straightforward operation. Nor are the problems limited to the technical sphere. International agreements on a wide range of financial and other issues would probably be required. Nevertheless, the Government is actively engaged in research and other exploratory work to help provide a sound technical foundation for any action that may need to be taken and internationally participates in the work of a special ICAO Committee set up to study this problem in depth.

The Government has already supported a substantial quantity of research work related to the noise characteristics of low-bypass ratio engines. Support for a further programme on the Spey engine to confirm certain design requirements for suppressing noise generated in the tail pipe has been agreed, and other proposals for further advances on technical and engineering aspects of retrokits are being pursued with industry.

The new generation of quieter civil engines and aircraft

The new higher bypass engines—the Rolls-Royce RB211, Pratt & Whitney JT9D, and General Electric CF6—have enabled the latest generation of aircraft (L1011, DC10, Boeing 747 and the A300 Airbus) to be a great deal quieter than that which it replaces. For example, under noise-certification conditions, the earlier medium-haul aircraft are operating with take-off noise levels of 100-108 EPNdB and 108-110 EPNdB on the approach.

The corresponding figures for the L1011 Rolls-Royce engined TriStar, the quietest of the new generation of large transports, are 98 EPNdB at take-off and 103 EPNdB on the approach or 10 to 15 less. This has been achieved in spite of an almost three-fold increase in take-off weight and power. It has been reasonably well established that annoyance due to aircraft noise arises from two sources:

(i) the noise from an individual aircraft movement, and
(ii) the number of times it is repeated.

Because new aircraft types are larger they will be able to accommodate the possible growth of traffic for some time without an increase in the number of movements. Moreover they are notably quieter than the type that have been in service for some years. Thus as more of the new wide-bodied jets come into service the total noise will diminish significantly. Another way of looking at it is to say that the area within the 90 PNdB contour for the TriStar, for example, is only about one-third of that for some of the older medium-range aircraft, which can carry only half as many passengers.

The TriStar is as stated powered by the Rolls-Royce RB211, manifestly the quietest of the new large engines. With the RB211, Rolls-Royce have clearly demonstrated their technical capabilities in the field of quietness. The same skills and concern to reduce noise levels are being applied in the development of the Olympus engine for the Concorde. The intention is to achieve the lowest possible noise level consistent with the special problems of a powerplant for supersonic operation. The development of these powerplants, and the advances in the technologies of engine quietening which they have achieved, have been assisted by very substantial technical and financial support from the Government. The development programmes themselves are founded on the research programmes supported technically and financially by Government both in industry and at the MOD(PE) National Gas Turbine Establishment, Pyestock and in universities.

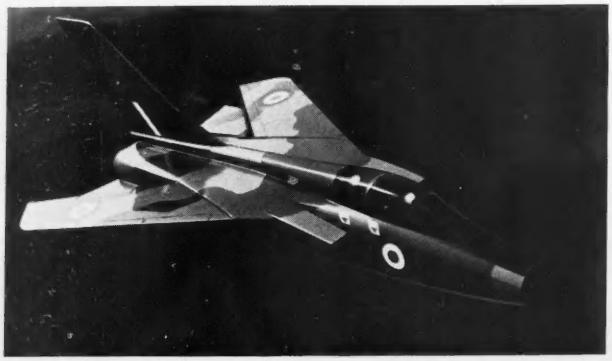
As would be expected, the emphasis in the research programmes changes as understanding builds up. Initially the main effort was aimed at reducing the noise of high and medium-speed jets. Higher bypass-ratio engines, with slower jet-exhaust velocities, were originally primarily conceived as a means of improving aircraft performance, but their potential for quietness was soon appreci-

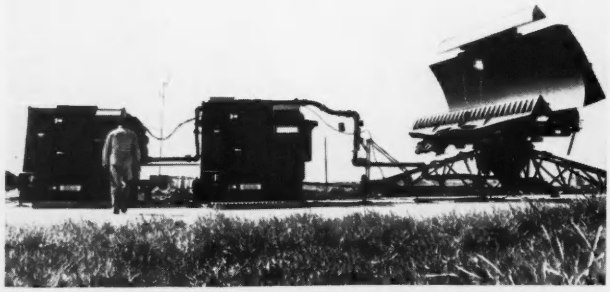
(continued on page v)

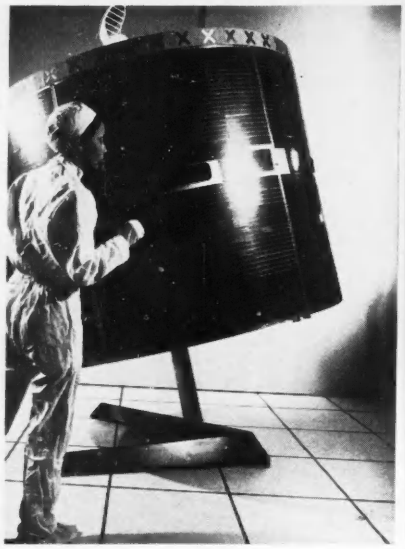
A Message from the Minister

This year's Farnborough is the largest ever and has a strong European flavour. This is particularly appropriate because the aerospace industry's future will depend increasingly on partnership across national boundaries. The show demonstrates the great achievements that have already sprung from such collaboration.
The British industry has an enormous amount to offer both its customers and its partners. Many British aerospace products are the most advanced in the world. During the past year our exports topped £300 million making Britain among the foremost of world suppliers.
Looking ahead the Government will continue to help British industry maintain its place in the world of aerospace. I am determined also to give high priority to protecting the environment. As this report shows we are in the forefront with research into the problems of aircraft noise and the development of quieter engines. With the new generation of aircraft this extensive research effort is now coming into practical application.
I am very glad to send my good wishes to everyone concerned with Farnborough 1972.

GEC-Marconi Electronics







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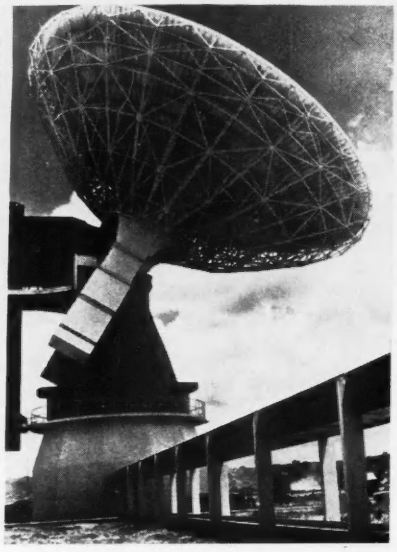

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Flying Exports

Earlier this month it was announced that the People's Republic of China had ordered another six Trident 2E jet airliners worth £23 million including spares. Further Trident sales are being negotiated both at home and overseas and total sales at August 9 last were 94 aircraft. Below we show some more of the reasons for Britain's outstanding success in aerospace exports.

A BEA Trident 3 en route over Cyprus.

A BEA photograph

QUIETER AIRCRAFT

(continued from page iii)

ated. But nothing comes easily in aircraft engineering. The quietening of the exhaust jet immediately threw the noise of the larger fans into sharp relief. As part of the attack on this problem, a Compressor Noise Facility was built at the Rolls Royce factory at Ansty, with joint Government/industry funding. In addition a new research facility for absorbers is now being commissioned at the NGTE, and another to deal with turbine and exhaust noise is being built.

More lift at low speeds

Noise is not the only intrusion on the environment by the modern jet airliner. The high landing and take-off speeds resulting from wings designed for economical high-speed operation result in long runways and hence large airports. High lift research aimed at improving the performance of wing lift systems at take-off and landing is being pursued intensively so that the next generation of aircraft will have much enhanced low speed performance permitting reduced runway lengths and hence smaller airports and more intensive use of existing airports. In combination with new types of quiet engine steeper landing and take-off flight paths should also be possible which could reduce air traffic congestion in flight and further reduce noise on the ground.

The leading-edge slot and trailing-edge slotted flap are the most widely used types of mechanical high-lift devices. Research is aimed at improving the performance of these devices, while increasing the designer's understanding of them. Tests are being done in wind tunnels at the RAE, BAC and HSA, and the structural and operating aspects are being studied by the aircraft industry. Increases in lift of over 20 per cent have been obtained. The wing illustrated on page ii is typical of the kind likely to be used on a future airliner.

The simplest way to increase lift beyond that obtainable from a purely mechanical flap is to allow the jets of air from the fans of underwing engines to flow on to and around the trailing-edge flaps. Externally blown flaps can develop at least 50 per cent more lift, depending on the engine power, compared to unaided mechanical flaps. A test model is shown on page ii.

The 74-89 seat BAC One-Eleven regional twin-jet airliner is now certified for operation from unpaved and gravel surface runways and has convincingly demonstrated this important new capability in South America—being the first jet ever to operate at 10 of the 21 airfields visited. The aircraft is already established in reliable service in South America, Africa and the South Pacific. More than 200 BAC One-Elevens of all types have now been chosen by 40 operators to serve destinations in 60 countries throughout the world.

The Britten-Norman Islander (built at Bembridge, Isle of Wight) is seen here in Olympic Airways livery. Britten-Norman Ltd have to date sold 340 Islanders, 7 Trislanders and 1 Defender to a total of 65 countries.

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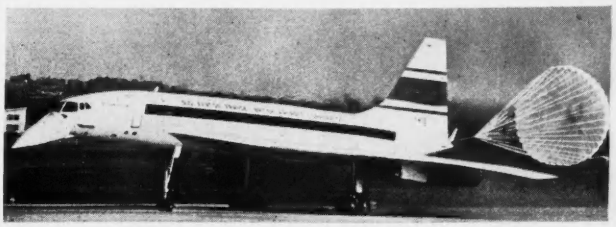
Hawker Siddeley Aviation has announced details of a new version of the popular HS125 business jet of which over 260 have been sold worldwide. The new version, known as the HS125-600, is powered by two Rolls-Royce Viper 601 turbo jets and has an all round improvement in performance over its predecessor the HS125-400. There has been a 2 ft. stretch in the passenger cabin, top speed has been increased considerably at altitude and whilst the aircraft can fly further than the 400 series, it has better field performance even at the increased weight. The aircraft is due to make its first public appearance at Farnborough this year.



The 31 ft.-diameter ribbon parachute for the Concorde project was designed and made by Irvin's Parachute and Government Products Division, Letchworth, Hertfordshire. The ribbon parachute gives a drag of approximately 18 tons at normal landing speed and was designed for use on Concorde 001 and 002 prototype aircraft. Irvin designed and developed the first brake parachute to be used for a jet fighter in the United Kingdom—the BAC Lightning—after work on its prototype aircraft and English Electric P1A and P1B. Irvin have also equipped the Avro Vulcan Mk. 1, BAC TSR2, BAC Bristol 188, BAC/SNIAS Concorde, Ilyushin IL 28 (for the Indonesian Air Force), the Saab Draken (for the Swedish Air Force) and the MIG 21 for the Finnish Air Force.

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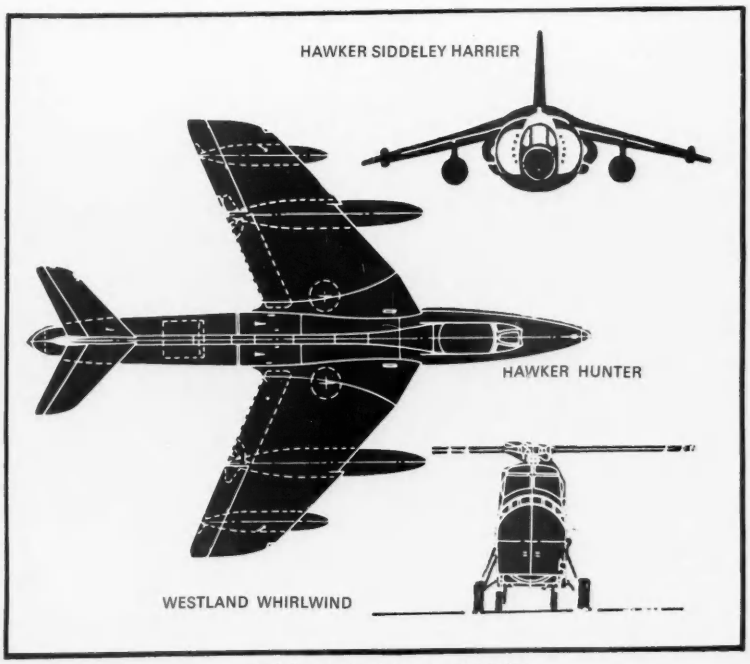

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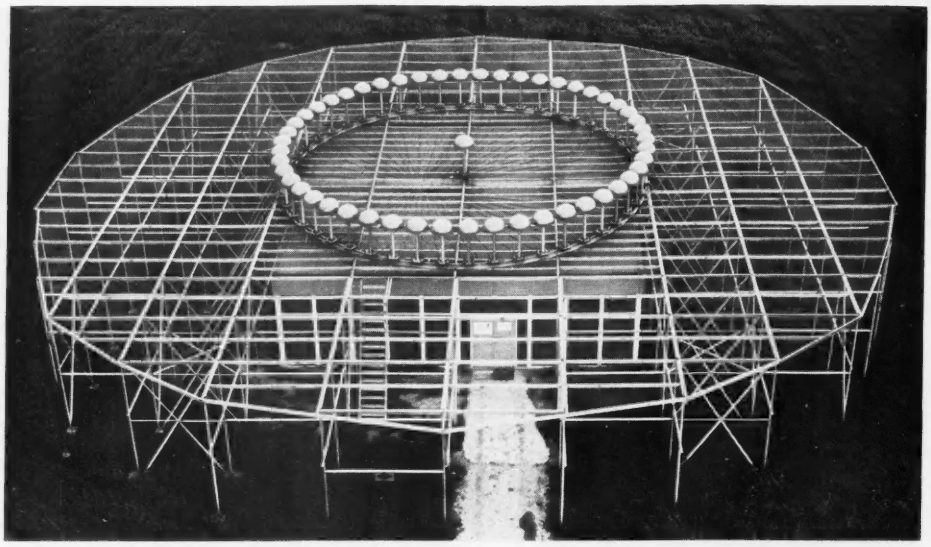
New Radio Beacons for UK's Air Traffic System



Britain's air traffic system is to be equipped with the latest improved navigational beacons under contracts being placed by the Civil Aviation Authority. The new beacons, (seen above) known as Doppler VHF Omni-range (DVOR), not only give greater course accuracy and better quality for pilots to navigate by, but are also more reliable, consequently requiring less maintenance.

The CAA is placing a first order for 15 DVOR at a cost of about £¾ million, including an initial contract for 10 from Plessey for their newly-developed 'Plan 50' equipment, and with Standard Electrik Lorenz for 5 of their current Doppler 'VOR-S' equipments to meet immediate needs. In addition, Plessey are to be contracted to undertake research aimed at further possible advances towards greater precision in air navigation.

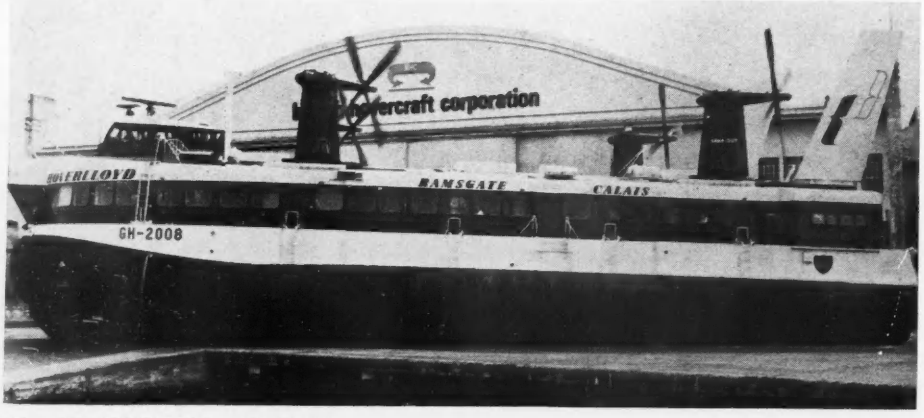
The VOR beacon, of which there are at present 43 in the UK, is the primary international standard radio aid to navigation. The DVOR's to be supplied are more precise and their siting not so critical, being less affected by terrain and other obstacles. The research to be undertaken by Plessey will, it is hoped, lead to further improvements which, by the introduction of additional equipment, will provide a Precision DVOR. It is envisaged that this will lead to closer track separation, enabling additional and parallel routes to be employed.

The export market for Britain could amount to some £20 million over the next ten years, with an early build-up in the next few year's as conventional VOR systems are replaced and extended by the new 'Doppler' technique. Delivery of the first Plessey sets will begin in mid-73. The total CAA requirement for VOR's over the next few years is believed to be for about 50 systems.

The A.300B European Airbus

Designed and built by major aircraft manufacturing organisations in Britain, France, Germany and the Netherlands, the A.300B is due to enter service in 1973. A number of Hawker Siddeley Aviation factories are co-operating in the construction of the wings. The A.300B is a high capacity (250-300 seats) short-medium haul airliner with new technology 'quiet' fan engines. Here the first A.300B European Airbus to be removed from its final assembly jigs is seen in the advanced assembly position for systems, equipment and engine installation.

Improved Hovercraft



In May this year the fifth 190-ton SR.N4 hovercraft to be built by the British Hovercraft Corporation with DTI collaboration was launched at East Cowes, Isle of Wight. Of the new features built into SR.N4-005 the most significant is its tapered skirt which provides a better performance, particularly in heavy weather, a reduction in the amount of spray generated in transit, and reductions in operating costs. Since the SR.N4 first entered service just over three years ago, it has carried over 2.5 million passengers and 350,000 vehicles on cross-Channel routes, and last year alone it accounted for nearly 30 per cent of the total passenger traffic carried across the Channel and over 25 per cent of all private vehicles.

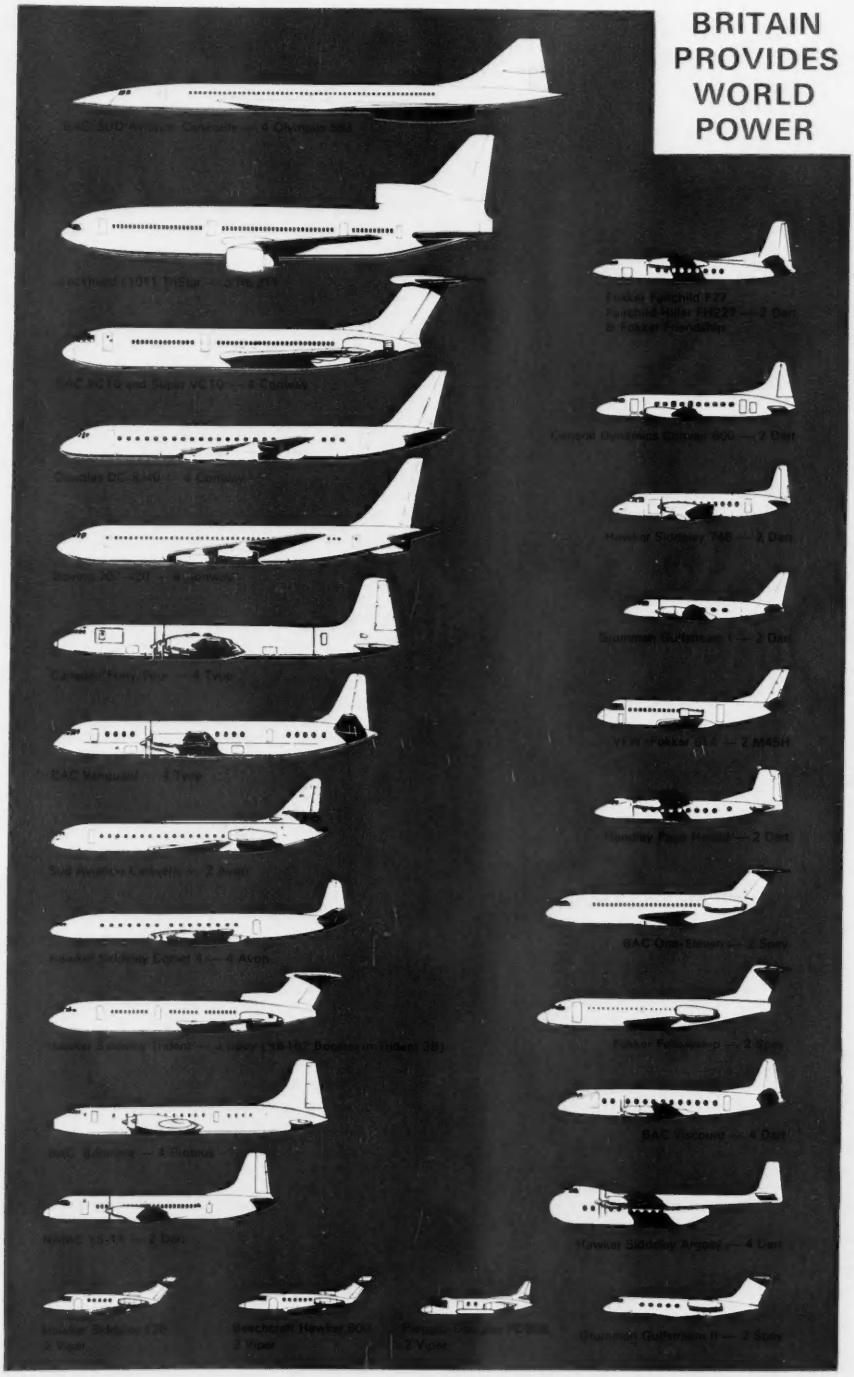
Better engines advance air transport

THE major contribution made by aero engines to the advances in commercial aviation was stressed in a paper read early last June by Mr. H. Pearson, assistant technical director, Rolls-Royce (1971) Limited, at the International Congress of Air Transportation Conferences in Washington. Some of the points made by Mr. Pearson were that a lesson of the postwar years has been that technical development—and of the powerplant in particular—has led the air transport business to rethink what at one time were considered fundamental limitations and widen its horizons to provide new standards of speed, safety, regularity, comfort and economy.

For example, in the US alone improvements in air travel during the 20 years up to 1968 has resulted in passenger time savings of 1,000 million man hours and passenger fare savings of over $8,000 million, plus $1,000 million savings in cargo tariffs. At the same time safety standards have been improved—in 1950 there were over three passenger fatalities per 100 million passenger miles according to ICAO figures for scheduled air transport. This had been reduced to under 0.3 fatalities per 100 million passenger miles in 1970.

The powerplant has a major effect on aircraft economics because it contributes about 45% of the direct operating costs (fuel and oil, maintenance, depreciation and insurance). It also influences another 40% because engine performance and weight affects the size of aircraft required for a given duty.

Over the past ten years engines for airliners have been developed which provide considerable advances in specific fuel consumption and thrust per pound of engine weight—also greatly reduced noise levels. This has been achieved without a significant increase in the price per pound of thrust. In addition maintenance and overhaul costs have been constrained.



The effect of these advances can be demonstrated by comparing the direct operating cost of a modern trijet such as the Lockheed TriStar powered by a modern high bypass fan engine, the RB211, with the operating costs of a trijet airliner designed to do the same job but using suitably scaled engines of earlier vintage.

If this aircraft had medium bypass ratio turbofan engines similar to an engine type which entered service in 1964, its direct operating cost would be 21% higher than the TriStar. And even if these engines had been supplied free of charge, with free spares throughout the aircraft life, direct operating costs of the trijet would still be 13% above those of the TriStar. Moreover, the earning capacity of the aircraft with the earlier-standard engines would be crippled by the tougher noise requirements which it would now be expected to meet.

Beneficial spiral

Improved economics lead to traffic growth and this has in turn demanded larger-capacity aircraft. Now as the design payload and hence size of aircraft increases there is a beneficial effect on operating economics—always provided the traffic is available. Air transport is thus characterised by a beneficial spiral of improved economics generating increased traffic, which leads to still further improvements in economics.

The improvement arises because all costs do not increase in proportion to the payload. As engines increase in size, their cost increases more slowly than their thrust because, for example, operations such as setting up machine tools, handling parts and assembly tend to be relatively independent of engine size. Thus the benefits of improved technology are enhanced by the increased size of the engines required for the increased traffic demand. In addition 'state of the art' improvement is needed to minimise the social handicaps of air transport, in particular the generation of noise and smoke.

An alternative means of increasing the productivity of aircraft besides making them larger is to make them faster. This brings us to the supersonic transport. There is every reason to expect that it too will progress along the road of better technology, improved powerplants and more attractive economics.

Air Safety reflects advances in ATC

Air traffic is increasing. So, fortunately, is the development of automated air traffic control systems. During the next few years, air safety must depend on how well ATC keeps pace with aviation progress and the corresponding increases in traffic density.

The Plessey contribution is to provide the air traffic controllers with the tools to enable them to continue with their efficient tasks.

These tools may be complete operational complexes like MADAP at Maastricht in Holland or MEDIATOR at West Drayton in England, or automated secondary radar systems, or primary and secondary radar heads, display and data processors for larger or smaller ATC systems, instrument landing systems . . .

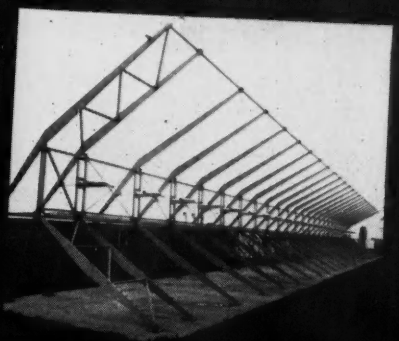
The common denominator is the long and specialised experience of ATC requirements that Plessey brings to the task of meeting today's and tomorrow's needs.

ATC requirements vary from country to country, from airport to airport, from airfield to airfield. Plessey manufactures a comprehensive range of equipment and systems; and its experience, at all levels, in most parts of the world, also means that Plessey is well placed to advise its customers on their ATC needs.

...reflects equipment progress by Plessey

The ***ACR 430*** *provides the smaller civil or military airfield with an inexpensive but versatile and high-performance radar; its twin-beam system caters for a very wide range of operational tasks.*

MEDIATOR*–daylight viewing screens make their own unique contribution to air traffic control, by way of unambiguously displayed data and reduced controller fatigue.*



Plessey ***ILS*** *and other navigational aids are playing an increasingly important role in the total systems package for world airports; these advanced systems will provide greater safety and efficiency factors, now and in the foreseeable future.*

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611 PRR

Military Aircraft

First Hawker Siddeley Harrier (AV8A) V/STOL fighter for the United States Marine Corps.

JAGUAR

Of the current military aircraft projects in which the British industry is collaborating with Europe, the earliest is the Anglo-French Jaguar, which originated from a 'memorandum of understanding' between the two Governments in May 1965.

The Jaguar is being built in five versions—tactical support for the RAF and the French Air Force, naval strike for the French navy, and two-seat trainer variants for both France and Britain.

The aircraft has been developed and produced by two specially

Jaguar

formed companies—SEPECAT (Société Européene de Production d'Ecole de Combat et d'Appui Tactique) a joint British Aircraft Corporation and Marcel Dassault/Breguet Aviation concern to produce the aircraft, and Rolls Royce-Turbomeca, to supply the engines. The Rolls Royce-Turbomeca Adour, two of which power the Jaguar, incorporates advanced technology which has resulted in a simple design containing a small number of parts. The Adour has been selected for the Japanese T.2 trainer and the HS 1182 trainer for the RAF.

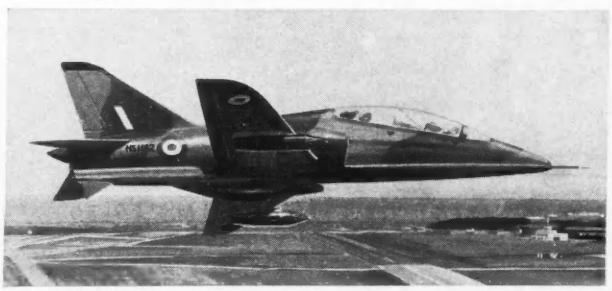
MRCA

Supersonic at all altitudes, the Jaguar is armed with two 30mm guns in the single-seat version and can carry 10,000 lb of external stores.

The first Jaguar prototype flew in 1968 and the first production models have recently been delivered to the French Air Force. Deliveries to the RAF will begin next year.

MRCA

The Multi Role Combat Aircraft, which is being developed jointly by the United Kingdom, the Federal Republic of Germany and



HS 1182 Trainer

Italy, is scheduled to fly at the end of 1972.

The aircraft programme is directed by a tri-national Governmental organisation, NAMMO (the NATO MRCA Management Organisation) and the actual design, development and production is in the hands of two tri-national industrial companies, Panavia (airframe) and Turbo-Union (engine). The British components are the British Aircraft Corporation and Rolls-Royce.

'Variable geometry' was chosen as the only wing configuration

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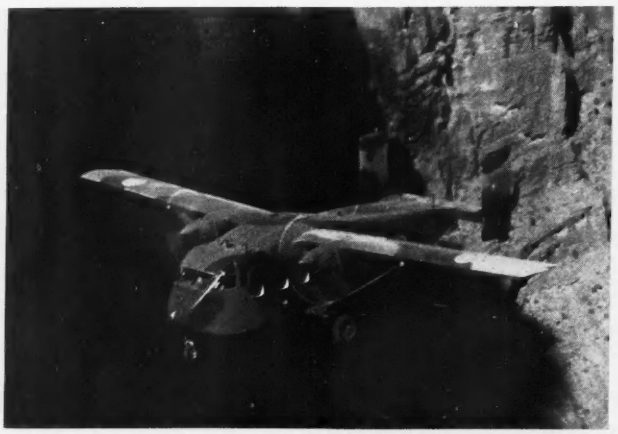


Short Brothers and Harland's Skyvan light STOL multi-role tactical transport which is in service with the armed forces of seven countries.

Versatile Nimrod will go a long way

Nimrod's Tactical Navigator has a 24 inch-diameter cathode-ray tube giving a continuous, north-stabilised picture of the tactical situation showing aircraft position and present and past track, sensor imputs and sonobuoy positions. Bearing lines and range circles from the sonobuoys, ECM bearings, MAD and visual and radar fixes are also represented on the display which covers 10 to 160 nautical miles dependent on which of the five scales is selected.

A smaller rectangular display gives related alphanumeric information, but can take over the situation display should the larger tube fail. Aircraft parameters, target track and speed, sonobuoy channel numbers and symbol lat/long co-ordinates are displayed.

A vital task taken over by the computer in the Nimrod system is the prediction of target position, track and speed from sonar active and passive fixes. Predicted intercept point and weapon splash and release points are continuously computed and updated as new fixes are obtained and as the aircraft position changes.

The Hawker Siddeley Nimrod MR Mk.1, the world's first land-based all-jet maritime reconnaissance aircraft, went into service with the Royal Air Force at RAF St. Mawgan in 1969.

Since then operational Nimrod squadrons have been formed at RAF Kinloss and at St. Mawgan, where the Maritime Operational Training Unit also operates Nimrods.

The Nimrod made its first flight in 1967. Under the initial government contract 38 aircraft were ordered. Delivery of this first batch is almost complete, and production of a further squadron of Nimrods, a requirement announced recently by the Government, is in the intitial stages. The full production stage of the aircraft for the squadron will have been reached by 1974.

High sub-sonic speed

Powered by four Rolls-Royce Spey turbofan jet engines the Nimrod is designed to fly at high sub-sonic speed and at high altitude to the search area. It can then search at low-level in a long-endurance low-speed patrol before a high speed return to base. Normal search speed with two of its four engines shut down is about 180 knots, with equivalent economy to turboprop aircraft in similar roles.

The main role of Nimrod with RAF Strike Command is maritime reconnaissance and anti-submarine activity. In addition to weapons and sonabuoys, the aircraft carries equipment for day and night photography. For night search operations, a searchlight carried in the starboard wing pod is used.

In addition to its sea/air warfare tasks Nimrod can carry out search and rescue operations, and can be converted to a long-range troop transport role.

Described as the most comprehensive airborne system yet to enter service with the Royal Air Force, the Nimrod carries a crew of 12 and some of the most sophisticated electronic equipment in the world.

At the heart of the system in Nimrod's central operations room is an Elliott MCS 920B digital computer which continuously processes information from the aircraft s sensors. Information comes from ASV radar used to detect surface shipping or submarine periscopes and snorkles, ECM equipment which detects and locates radar sources, and an exhaust trail indicator which traces diesel exhaust in the air, and sonabuoys dropped from the aircraft to detect moving or stationary submarines and give range and bearing data. Another sensor, the magnetic anomaly detector in the tail boom, detects submarines from their disturbance of the earth's magnetic field.

Information from the sensors is processed by the computer and displayed at the tactical navigator's position on a 24 inch diameter cathode ray tube. From the information, the computer can predict target position, track and speed. Predicted intercept point and weapons release points are continuously computed and updated as new fixes are made and the aircraft's position changes.

The aircraft is provided with back-up systems to ensure the successful completion of a mission in the event of a failure, and full play-back facilities are provided.

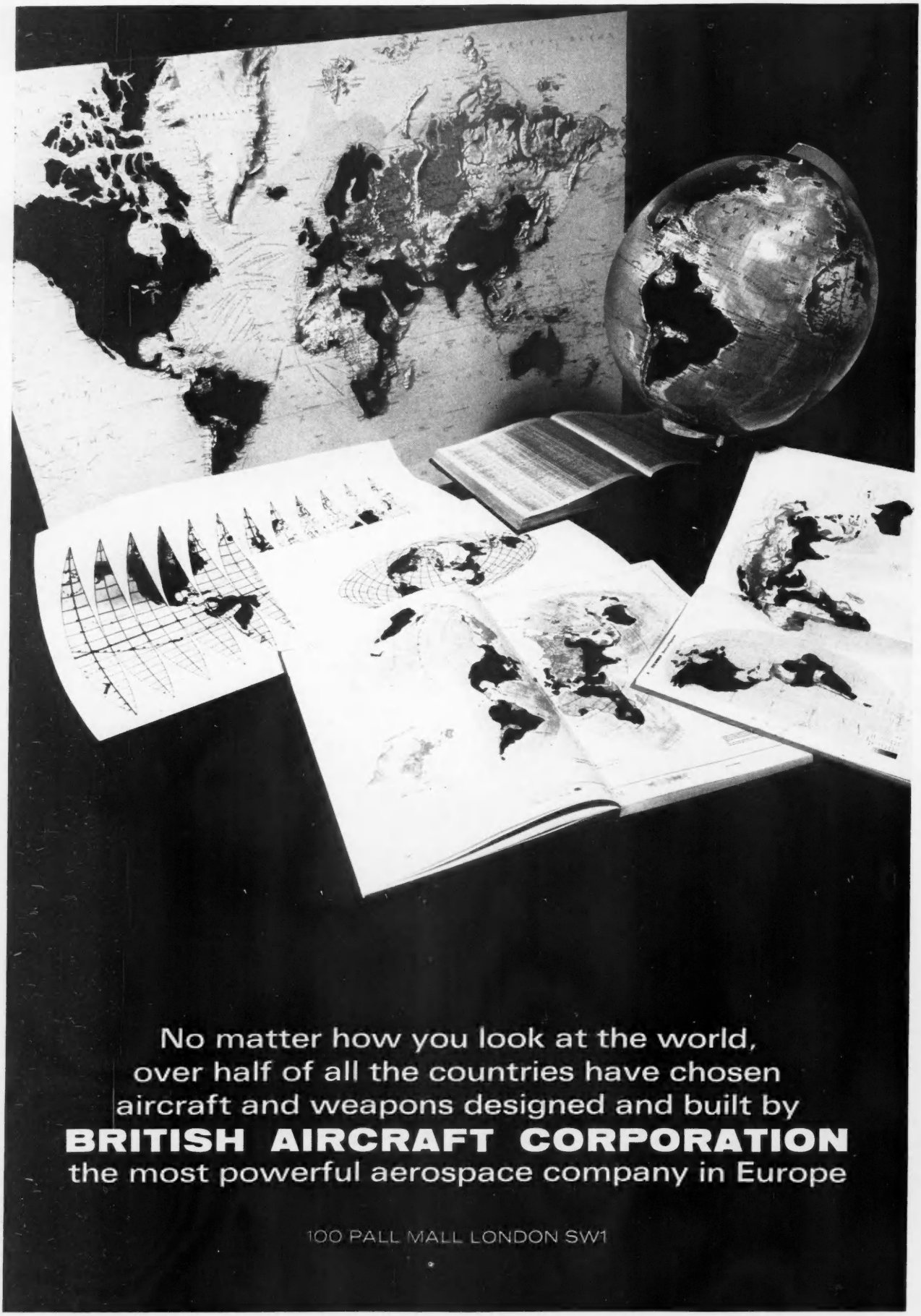
Despite the high degree of automation, the crew is kept fully in the loop to contribute maximum use of experience and decision-making capability.

Power for future developments

Nimrod has ample space and power supplies to take new equipment as it becomes developed or additional equipment for specialized roles.

Nimrod beats the RAF target for sortie availability and shows a significant reduction in maintenance costs over existing types. It requires less than 18 maintenance-man hours per flying hour.

Crew comfort is enhanced by the absence of noise and vibration in Nimrod, its air-conditioned interior and its high transit speeds which cut down total airborne time. The roomy fuselage adds to comfort, and additionally a small dining room is provided for meal breaks.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over half of all the countries have chosen
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MILITARY AIRCRAFT

(continued from page xii)

which could meet the various and exacting demands of the three partner countries. With wings swept back the MRCA will exceed Mach 2 at high altitudes—yet it will land and take off with wings swept forward at very low speeds on short advanced strips. With wings at the optimum sweep for economical cruising it will have a long range. 'Variable geometry' permits prolonged high speeds at very low altitude, and low 'gust response'—which means a comfortable ride for the crew and the maintenance of their maximum fighting efficiency.

The Turbo-Union RB-199 engine made its first bench test run in 1971 and the first of nine prototype and development aircraft is scheduled to fly at the end of 1973. About 900 MRCAs are planned to be built under the largest joint military project yet tackled by a European group of companies.

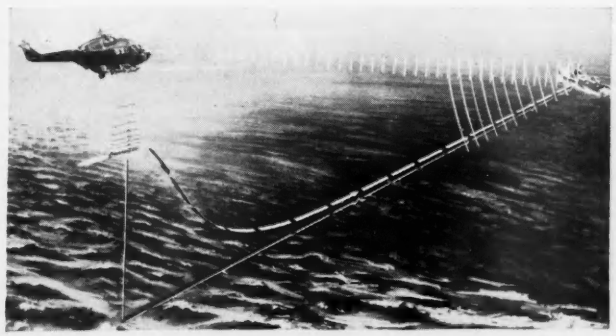
Helicopters

Gazelle

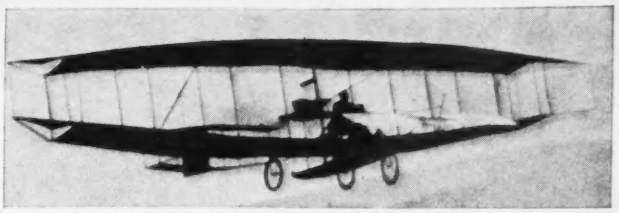
The Anglo-French package deal on helicopter collaboration covering production of the Puma, Gazelle and Lynx, dates back to 1967. The main contractors are Westland Helicopters and Societe Nationale Industrielle Aerospatielle (SNIAS) for the airframe and Rolls-Royce and Turbomeca for the engines.

Development of the SA 330 (which carries 16 fully equipped troops) was well advanced in France when collaboration began, and the aircraft entered RAF service in the tactical transport support role in 1971.

The SA 341 Gazelle, an advanced light five-seat observation helicopter, is currently being developed under SNIAS leadership for use by the British and French armed forces. The larger WG 13 Lynx, which can carry 10 fully equipped troops, is being developed under Westland leadership for various military and naval roles.



The British Government has given the British Aircraft Corporation's Guided Weapons Division the go-ahead for the first stage of a new missile project for the Royal Navy, at present named CL 834 seen here as the basic system concept. The new system will be eminently suited to the requirements of a large proportion of overseas navies, giving it a considerable export potential.
The lightweight CL 834 missile will be installed on Royal Navy 'Lynx' helicopters, to provide long-range self-defence for frigates against missile-carrying fast patrol boats, hydrofoils and hovercraft.



The A.E.A. (Curtiss) 'June Bug': 1908

Aviation:

An Historical Survey from its Origins to the end of World War II by C. H. Gibbs-Smith

This, the first of two volumes, contains an historical narrative together with a table of first flights, a chronology, glossary and bibliography. There are 127 half-tone illustrations 128 line drawings and 5 throw out tables.

'This is a fine volume worthy of the best that Her Majesty's Stationery Office produces'. AEROSPACE **£2.50** (£2.74)

Space Research Report 1969-70

An illustrated publication by the Science Research Council which is divided into three parts and consists of reports from university investigators who have received space research grants; from the SRC and Government establishments carrying out space research programmes; and from investigators undertaking analyses of samples of lunar surface material returned to Earth by the Apollo 11 and 12 missions. **£1.20** (£1.27)

British Industry Today

Aerospace

The aircraft industry in Britain is, in size, second only to that of the United States among countries in the Western World. This informative booklet covers development, structure and location of companies, output, types of aircraft, helicopters, engines and missiles and space activities. (COI Reference Pamphlet 104) **47p** (50½p)

Clément Ader:

his Flight Claims and his Place in History

In this book the author examines the merits of the claims that Ader flew before the Wright Brothers and sets out the historic facts as contained in the records and documents.

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The aim of this book is to explain some of the priniciples and technical requirements of space flights. It describes the nature of space and astronautics, space vehicle systems, navigation and guidance, and the human factors involved.

£1.05 (£1.26)

Sir George Cayley's Aeronautics 1796-1855

For the first time the whole story of Caley's Aeronautics is fully documented and described in this book. The author has drawn widely on hitherto unpublished material and presents a detailed account of all Cayley's ideas, designs, models and full-size machines. There are 80 illustrations in the text and 6 half-tone plates.

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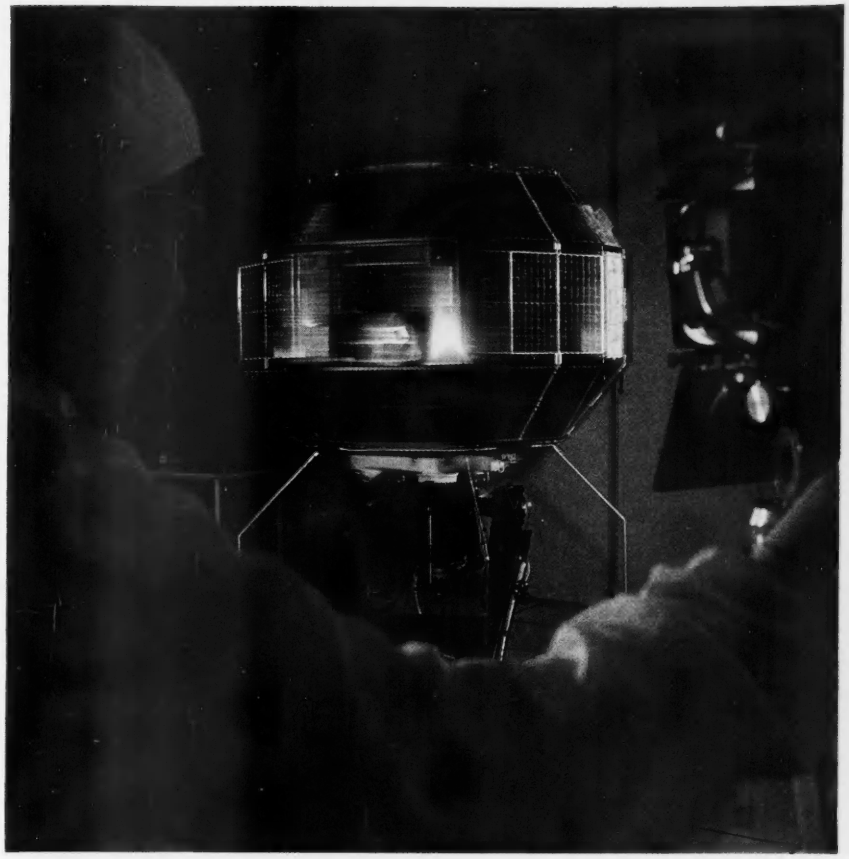
Expanding activities in space



The Prospero satellite undergoing prelaunch tests

Photo: John Lawrence for Marconi

The UK is involved in an expanding range of space activities. Several UK spacecraft are already in orbit and more are planned and the UK is also participating in several international space programmes.

The Department of Trade and Industry (DTI) is not, of course, the only government department with an interest in space matters. The Ministry of Defence is concerned with defence communications satellites, meteorological satellites and with spacecraft procurement for other departments. The Department of Education and Science has an interest through the Science Research Council which carries out scientific space research and which has its own series of scientific satellites (ARIEL 1 to 4). The Ministry of Posts and Telecommunications is concerned with communications satellites and the Post Office represents the UK in INTELSAT, the international commercial communications satellite organisation. The DTI has two major related areas of interest in the space field; it is the sponsoring department for the UK space industry and it is also responsible for much of the UK participation in international space activities and in particular for use of satellites in air traffic control and marine navigation where they are an extension of other aspects of DTI's responsibilities.

The most important part of DTI's industrial sponsorship role is the National Space Technology Programme (NSTP). The main purpose of the programme is to assist the UK industry to build up its capabilities and widen its experience in spacecraft technology so that it will be well equipped to supply the necessary hardware for domestic satellite programmes and to compete in world markets for scientific and applications satellites. The NSTP aims at anticipating the advanced technologies which will be needed in communications, meteorological and other types of spacecraft for the rest of the 1970s and beyond.

The main activity in the NSTP is a series of technology satellites which are used for testing in space new spacecraft systems and components. Once such systems have been orbited successfully in space they can be used with confidence in communications and other applications satellites.

PROSPERO (Previously known as X3) was the first of DTI's technology satellites and was launched from Woomera, Australia, in October 1971. Its main purpose is to test new lightweight solar cells, advanced electronic techniques, paints and plating finishes, power supply electronics and telemetry and telecommand systems. It also carries a scientific experiment—provided by the University of Birmingham—measuring the incidence of micrometeoroids. Its performance in orbit has been excellent. It is designed to operate for at least one year although it will remain in orbit for much longer. The main contractors for PROSPERO were the British Aircraft Corporation and Marconi Space and Defence Systems (part of the GEC Group) while the Royal Aircraft Establishment Farnborough

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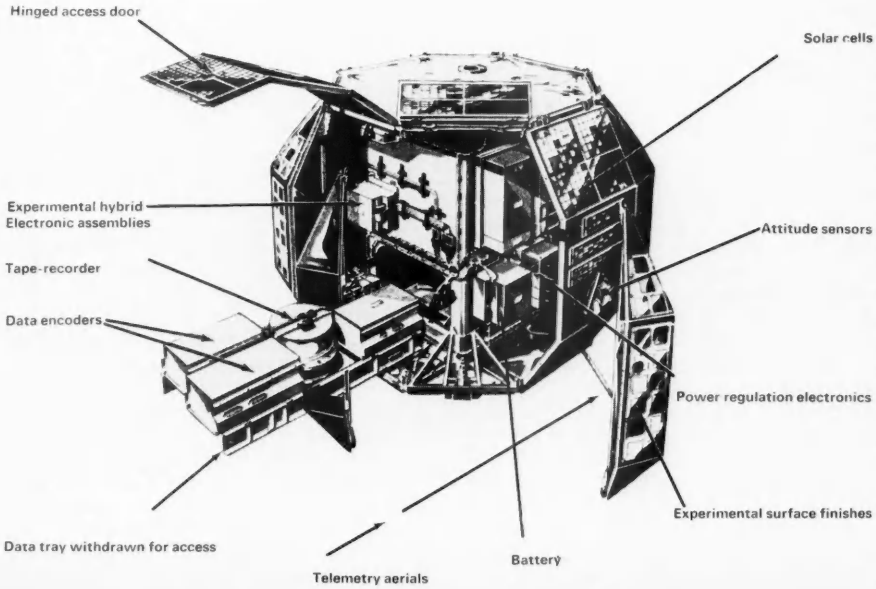
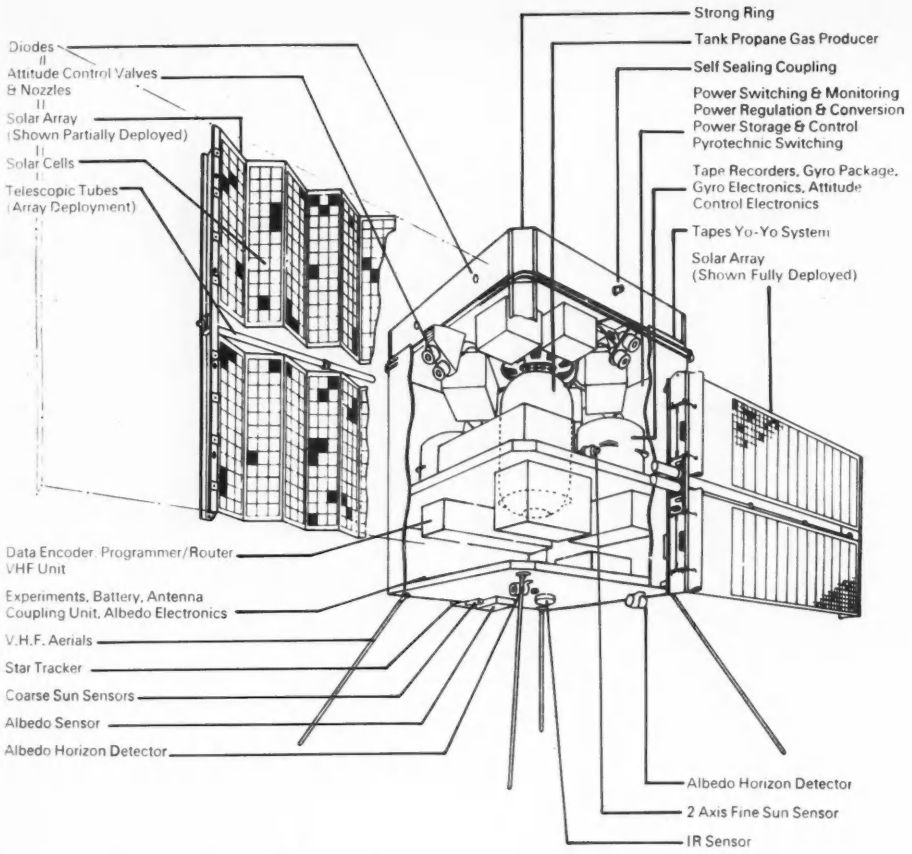


Prospero opened up



Weight of Spacecraft	95 Kgm maximum
Length (excluding Antenna)	835 mm
Length (including Antenna)	1300 mm
Width across faces	665 mm
Span (Flexible Panels Deployed)	2500 mm
Circular Polar Orbit	750 Km
Launch	Early 1974

The X4 satellite

X4 will be a 90 kg three axis stabilised experimental spacecraft. It will carry an extendable solar cell array. The prime experimental package is the attitude control system comprising four main sections:

1 *An inertial platform indicating any change in orientation of the satellite with respect to its three major axes.*

2 *The sun sensors which enable the satellite to be locked on to the sun. Information from other experimental sensors allows additional reference points, e.g. the star 'Canopus' to be used.*

3 *A control logic system takes the above information and translates it into appropriate commands to the gas-jets which produce the pulses which position the satellite.*

4 *A propane system of six jets, The fuel supply of liquefied propane has capacity for 12 months of normal operation.*

was design authority. PROSPERO's orbital operations are controlled from RAE Farnborough.

The second in DTI's series of technology satellites is X4 which is due for launch early in 1974. X4 will be testing in space the first UK-designed 3-axis attitude control system and new sun, star and horizon sensors together with an unfurlable solar array. The satellite is at present under construction by the prime contractor, Hawker Siddeley Dynamics.

In conjunction with this series of satellites, there is also a programme of basic spacecraft technology research work. This programme, part of which is carried out in industry and part in RAE Farnborough and other research establishments, consists of research into various aspects of spacecraft systems such as attitude control, power regulation and storage, sensors, structures, telemetry and thermal control.

The question of future technology spacecraft is still under consideration in the light of foreseeable satellite requirements, UK industrial capability and European programmes.

A further part of the NSTP is the development of the Skylark rocket for work in remote sensing of earth resources. Skylark was originally developed as a sounding rocket (a rocket which carries scientific instruments into space but does not put them into orbit) and in this role has achieved considerable success. In this new development, the stabilised version of Skylark is fitted with cameras so that high altitude photographs can be taken of a large area of the earth's surface. These can be used for assessment of crops, plant disease, forests and mineral resources. A wide range of films and cameras may be used and these are recovered after each firing. The first launch of Skylark in its new role took place successfully at Woomera in March 1972 and further firings are expected to be made in Argentina early in 1973. Development work on the new system has been carried out by RAE Farnborough and the British Aircraft Corporation is the prime contractor for Skylark.

DTI has full policy and financial responsibility for the National Space Technology Programme. The Procurement Executive of the Ministry of Defence is responsible for some of the technical management of the Programme, for technical advice and for procurement of spacecraft and associated hardware. Much of this work is carried out in Space Department at RAE Farnborough.

The major companies in the UK space industry are the British Aircraft Corporation (BAC), Hawker Siddeley Dynamics (HSD) and Marconi Space and Defence Systems (MSDS) (part of the GEC Group). All three are closely concerned with various aspects of British space activities.

BAC and MSDS were the main contractors for the PROSPERO satellite and for the Science Research Council's ARIEL III and ARIEL IV scientific satellites. BAC is also the prime contractor for the Skylark sounding and earth resources rocket and has just completed work on the INTELSAT IV satellites as a major subcontractor to Hughes of USA. HSD is prime contractor for DTI's next technology satellite X4. MSDS is prime contractor for the Science Research Council's next scientific satellite UK 5 and for the Ministry of Defence's military communications satellites, SKYNET II. There are also a number of other companies operating in specialised areas in the space field, including Ferranti in solar cell research and Bristol Aerojet in small sounding rockets and sounding rockets motors.

DTI has a number of interests in international space activities.

The Department provides the lead for the UK Delegation to the European Space Conference, the forum in which the broad policies of European space activities are discussed.

DTI is also responsible for UK participation in the European Space Research Organisation's (ESRO) applications satellite programmes. At a meeting of the ESRO Council in December 1971, it was agreed that the Organisation's Convention would be revised to enable ESRO to undertake programmes of applications satellites in addition to its existing scientific satellite programme. Provision has been made for aeronautical, meteorological and communications satellites and the UK and most of the other ESRO members

Skylark explores the earth from space

A Skylark rocket, which was successfully launched from Woomera in March, has demonstrated for the first time the use of this rocket, originally designed at RAE Farnborough, as a means of examining the earth's natural resources from high altitude.

Mr. Michael Heseltine, Minister for Aerospace, said at a Press Conference 'In recent years photographs taken on the American Gemini and Apollo missions have brought home to us all how clearly the features of this earth can be seen from Space—especially geological formations, and vegetation. The importance of this new information about the earth and its resources is being appreciated increasingly both by advanced and developing countries.

'As a means of remote sensing, Skylark will provide an inexpensive alternative to aircraft and satellites for those countries that seek to know more about the potentialities of their own territory.

'Skylark already has a long history of scientific experiments to its credit and a record of reliability second to none. We have every hope that it will repeat its success in its new role'.

Woomera trial

Specially selected test areas in South Australia were photographed by cameras in the rocket at altitudes of between 150 and 190 miles. Instruments and cameras were recovered and evaluation of the data they contained is being carried out by the University of Reading and the Commonwealth Scientific and Industrial Research Organisation with co-operation from the South Australian Mines Department.

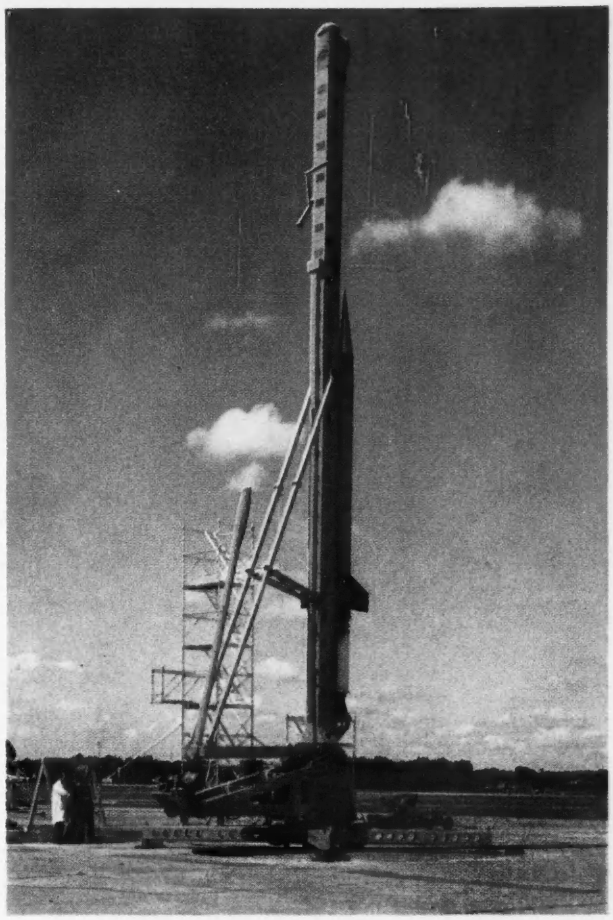
The project was sponsored by the Department of Trade and Industry as part of its National Space Technology Programme (NSTP). This programme, which plays a major part in DTI's sponsorship of the UK space industry, involves the development of new space techniques, systems and components. Its purpose is to give the industry greater experience in the field and thus enable it to compete more effectively in world markets.

The Ministry of Defence (Procurement Executive) has been responsible for the management of the project. The rocket payload was built and equipped with instruments and special cameras by RAE Farnborough with the main rocket sub-assemblies and motors being supplied by the British Aircraft Corporation who are Skylark prime contractors.

Remote sensing payload

The rocket carried a prototype remote sensing payload. Its primary aim was to test the stabilization control system and to flight-prove the remote sensing hardware, which in this case consisted of two cameras. It was successfully launched from the Woomera range using the solid propellant Goldfinch Boost Motor and Raven Sustainer Motor. These propelled it to an apogee of 287km during its nine minutes flight and it was recovered within 30 mins. after landing by parachute.

The payload was stabilised in three axes, two axes having Earth Albedo horizon sensors and rate gyroscopes, the third axis had a rate gyroscope only. Horizon sensors detect the difference in the sunlight reflected from the earth and from space. The latter is effectively zero.



The Skylark rocket is seen here on the RAE mobile launcher at Farnborough.

The major axis of the payload was stabilized to be horizontal, with the cameras pointing at the Earth but inclined to the local vertical. To build up a photographic coverage of the ground, a programme of six manoeuvres was performed during flight to rotate the payload in sixty degree steps about its vertical axis.

Coverage of 40,000 square kilometres

The Hasselblad camera was loaded with an infra-red false colour reversal film and exposed through a yellow filter. This gave an estimated ground coverage of 40,000 square kilometres per frame and a calculated ground resolution of 150m. The film is sensitive

EXPANDING ACTIVITIES IN SPACE *(contd. from p. xvii)*

have decided to participate in these programmes. UK space companies are members of the three European industrial consortia (STAR, MESH and COSMOS) which compete for ESRO satellite contracts. The UK companies have already carried out a fair amount of work on ESRO's scientific satellites and can look forward to a good share of the work on the applications satellites.

DTI is acting as co-ordinator for the various UK groups which are participating in use of data from the US ERTS (Earth Resources Technology Satellite) satellite programme. The first of these, ERTS-A was launched on July 23, 1972. UK groups are using this data for such work as detection of potential locust-breeding sites, experimental cartography and geological research. The US is currently considering proposals from various UK groups for participation in the Earth Resources Experimental Package, one of several experiments which will be carried out in Skylab. Skylab, the orbiting laboratory is due for launch towards the end of the year.

DTI is playing a very significant role in the development of the UK's space activities. The Department recognises the considerable potential in the use of space and is using its best endeavours to keep the UK in the forefront of all new developments.

More information: Where possible, items in *New Technology* indicate the best sources of further information. Readers are advised also to seek information on matters relating to *New Technology* from the following DTI regional offices: Edinburgh, 031-225 1822; Cardiff 62131; Newcastle upon Tyne 27575; Manchester, 061-832 9111; Leeds 38232; Nottingham 46121; Birmingham, 021-643 8221; Bristol 21071; London and South East, 01-684 9781; Eastern, 01-828 4355. In Northern Ireland, information is given by the Dept. of Industrial and Forensic Science, Belfast 21722.

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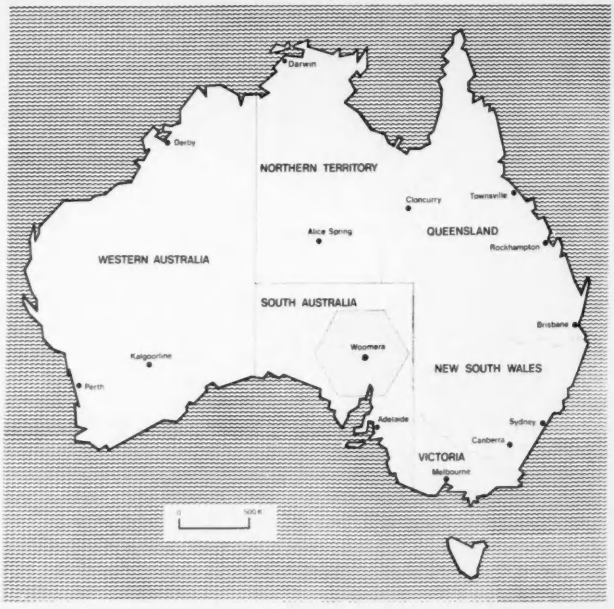
Down under from up high

This photograph was taken by a DTI-sponsored satellite from an altitude of 270 km using a Hasselblad 500 EL/70M camera with a Zeiss 80 mm lens through a yellow filter. The film was Kodak infra-red aerochrome. Area shown is about 40,000 sq. km and the calculated ground resolution is about 100 m. This frame shows the southern end of Lake Eyre, a salt lake which appears as the white blob at the top of the picture, patterns of bright river beds draining towards the lake. The white blobs towards the right are clouds, their black shadows on the earth. The solar altitude at the time of the photograph was about 40 degrees elevation which means that the height of the clouds was in the region of 10 km. Although the photograph is largely brilliant green this is, in fact, an arid desert region lying about 200 km NNE of Woomera and the green is actually showing the pinky-white dust of the desert in the autumnal March, the ground temperature being over 90° F.

to infra-red radiation between 700nm and 900nm in addition to visible light and renders visible the infra-red radiation reflected from vegetation and crops.

The choice of emulsions and filters was broadly similar to that used in the Apollo 9 multiband photography experiment, photographs from which have been interpreted by various groups of workers in the USA. Space photography in conjunction with photography from high altitude aircraft was used to estimate the volume of timber in Mississippi and Georgia, thereby reducing the sampling error from 31 per cent to 13 per cent; in addition, they showed that infra-red false-colour reversal film provided the best imagery for forest surveys. Workers analysed the photography of Imperial Valley, California using a scanning micro-densitometer and a statistical pattern recognition technique. They showed that automatic recognition of fields of barley, sugar beet and alfalfa was possible, with recognition accuracies of 75 per cent, 59 per cent and 27 per cent respectively. Earth Resources Skylarks provide imagery which is comparable to that obtained from Apollo 9 and shares some of the advantages over conventional high altitude photography.

The Earth Resources Skylark has several advantages over a satellite, in particular a free choice by the user of the launch time, in order to observe particular transient phenomena and to avoid cloud cover, freedom to vary the sensors on the payload; a much shorter planning time, measured in months rather than years; and considerably lower cost.



DTI at Farnborough

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